



Washington University in St. Louis

JAMES MCKELVEY SCHOOL OF ENGINEERING

POLICIES AND REGULATIONS

**Governing PhD Students in
the Department of
Biomedical Engineering**

2020-2021

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POLICIES AND REGULATIONS FOR PHD STUDENTS IN BIOMEDICAL ENGINEERING

1. REGISTRATION

All graduate students are matriculated into the Washington University Graduate School (<http://graduateschool.wustl.edu/>). Registration takes place each semester on the dates announced by the University. Detailed instructions for registration plus necessary materials are communicated directly to all graduate students enrolled during the previous semester.

All graduate students pursuing a degree in the department must register each semester until all degree requirements are completed. Students register in courses and/or research credits until they have earned the total number of credits required for their degree. PhD students register for nine credits of courses and/or research each semester until 72 credits are completed. After earning the required number of credits and fulfilling the course degree requirements, the student requests registration from their adviser or the Doctoral Program Coordinator for one of the following:

LGS GSAS 9000

LGS GSAS 9001

LGS GSAS 9000 - Full-time Graduate Research/Study that indicates the student's full-time engagement in research or academic writing until graduation. Students will be administratively registered in LGS GSAS 9000 based on recommendations from their advisers stating that the students are making satisfactory progress toward their degrees.

LGS GSAS 9001 - During a student's period of regular registration, they may have a need or opportunity to study away from Washington University. Recommendations from departments for students' registration *in absentia* will be considered by the Graduate School on

a case-by-case basis. If approved by the Graduate School, these students will be registered for LGS GSAS 9001 Full-time Graduate Study in Absentia. Students may be allowed to register for LGS GSAS 9001 for up to four consecutive or non-consecutive fall/spring semesters. Semesters in which a student is registered in absentia are counted as part of the student's program length.

Full-time students registered within the program and making satisfactory academic progress are eligible to receive a stipend, tuition remission, and the health/dental insurance and wellness fee subsidies. Tuition each semester will be calculated based on the number of registered course credits.

Inactive: Students who have not completed their course requirements but who, because of personal reasons, must suspend their studies may request a leave of absence with the approval of their adviser, the Director of Doctoral Studies, and the Graduate School. See the Graduate School website on leaves for further information - http://graduateschool.wustl.edu/current_students/leaves.

Students who fail to register in one of the previously mentioned categories will automatically have their graduate standing revoked. See the Graduate School Bulletin for further information.

2. ADVISING

Academic Adviser: Each entering doctoral student is assigned to the Director of Doctoral Studies as his/her academic adviser. After students pass their qualifying exams, their academic advisers switch to their thesis research mentors unless they move to a lab outside of BME, in which case the Director of Doctoral Studies will remain their academic adviser.

Rotation and Research Mentors: Each doctoral student is required to participate in at least one research rotation. A research thesis completed as part of a Master's degree at another institution or at

Washington University may count as one rotation. Rotations typically consist of contiguous periods of independent research in a mentor's laboratory, typically 8-12 weeks of research effort. Rotations serve two primary purposes for students: to inform students in their choice of a doctoral research mentor and research project, and to gain skills and knowledge in the conduct of laboratory research. Each rotation will have a rotation mentor who is a 'Primary' or 'Affiliated' faculty member of the BME department. Please see the department website for current members of the faculty:

<https://bme.wustl.edu/research/areas/Pages/default.aspx>.

Within each 'Research Area', the faculty consists of both the 'Primary' and 'Affiliated' members. The 'Primary' faculty members are the tenured/tenure track BME faculty members who are listed here: <https://bme.wustl.edu/faculty/Pages/default.aspx>.

For the full list of the 'Affiliated' BME faculty members, go to <https://bme.wustl.edu/faculty/Pages/affiliated-faculty.aspx>.

Only 'Primary' or 'Affiliated' faculty members of BME may serve as research mentors of PhD students. The rotation mentor will be responsible for outlining the student's project, as well as reviewing and approving the student's report at the end of the rotation. If a PhD student has already been accepted as a continuing student into the research team of a faculty member, the student may indicate their commitment through communication with the Director of Doctoral Studies followed by a verification with the thesis research mentor (*i.e.*, filling out and signing the **Doctoral Student Lab Affiliation Form**. Refer to Section 2.4 below for more information). The student indicating continuing status in a mentor's laboratory, is eligible to take their qualifying exam at any point in order to qualify for doctoral candidate status, but no later than **June 30** during the first academic year.

The choice of a research mentor and an appropriate thesis project will have a profound effect on the career of a PhD student. To aid the PhD student in these decisions, the following procedures put in place:

2.1 Rotation Preference Sheets

At the start of the academic year, the BME faculty will be invited to meet entering doctoral students to discuss their research programs. It is the responsibility of the student to request the opportunity for a research rotation with the proposed mentor, to determine if there is sufficient overlap in interests, as well as adequate space and resources to support the student throughout the rotation period. For each rotation, the student will submit a Rotation Preference Sheet to the Director of Doctoral Studies and the Doctoral Program Coordinator identifying his/her first, second, and third choice of the labs in which to do rotations. The Director of Doctoral Studies is available to discuss the process of selecting research rotation mentors during orientation and throughout the first year as students' progress through their rotations.

2.2 Rotation Selection

It is the responsibility of the student to update the Rotation Preference Sheet periodically in consultation with the Director of Doctoral studies and the Doctoral Program Coordinator. All grades for each research rotation will be filed by the Director of Doctoral Studies based on communications about research rotation preferences, reports, and evaluations.

2.3 Rotation Requirements

Each student will complete at least one rotation during their first academic year in the program. Rotations consist of contiguous periods of independent research in a mentor's laboratory, typically 8-12 weeks of research effort. Rotations may coincide with the fall and spring semesters; however, students are encouraged to seek a new rotation upon natural completion of their current research rotation. In practice, students may begin new research rotations at several intervals, but they must consult the Director of Doctoral Studies when doing so. Typically students will spend at least 15-20 hours/week on rotations while classes are in session and at least 40 hours/week when classes are not in session. For each rotation, students will register for three credits of BME 601C 30 that is led by the Director of Doctoral Studies. A rotation report is due at the end of each rotation

(see PhD Checklist on Page 30 for relevant dates). The rotation report and evaluation are the primary documents for the grade assigned for the rotation. Because PhD students do not register for courses in the summer, any rotation outside of the fall or spring semester is not taken for credit or as a course.

The first required rotation should commence as soon as a rotation lab is agreed upon. The second or third optional rotation should commence as soon as the previous rotation ends. The students must notify the Director of Doctoral Studies, the Doctoral Program Coordinator, and the rotation mentor if he/she wants to take time off (see Section 5.3).

2.4 Selection of a Thesis Research Mentor

At the end of each rotation, the rotation mentor will complete an evaluation of the student. These evaluations will become part of the student's permanent file and will be considered by the qualifying exam committee during the qualifying examination (see Section 3.3). Although some students choose to stay in their first rotation labs for thesis research, most students complete at least two rotations and identify a thesis research mentor from amongst their research rotation mentors by the end of the second semester. If this is not practical, students must identify a thesis research mentor by the end of their first 10 months in the PhD program. The student's thesis research mentor (also called "doctoral adviser") will usually be one of his/her rotation mentors. The thesis research mentor must be a current BME 'Primary' or 'Affiliated' faculty member. The faculty member must agree to be the research mentor through an approval process initiated by the Doctoral Program Coordinator. During this process, the **Doctoral Student Lab Affiliation Form** should be filled out and signed by both the student and the thesis research mentor. Selecting a research lab for pursuit of doctoral research is a process involving close communication between the proposed mentor and student, and that communication should begin early and be ongoing throughout the research rotation.

At any point, if the student and mentor agree that the student will

continue his/her doctoral research in the mentor's lab beginning January 1 of the first academic year (i.e., the rotation mentor is selected as the thesis research mentor), then the student must inform the Director of Doctoral Studies of his/her intent to do so. In this case, the student should take the qualifying exam at any time when they are ready but no later than **June 30** of the first academic year (see PhD Checklist on Page 30 for relevant dates).

2.5 Qualifying Examination Committee

After no less than one complete research rotation, the student may elect to stand for the Qualifying Examination. At that time, the student will first collaborate with the thesis research mentor to identify three areas of core knowledge considered essential to pursuit of doctoral research in the mentor's laboratory. These core areas of knowledge should fall under the umbrella of biomedical engineering. They will serve, in part, as the basis for questioning during the qualifying examination. Therefore, they should be areas where the 'Primary' or 'Affiliated' faculty members of BME have expertise.

After these three areas of core knowledge are identified, the student is to discuss a suggested three-member committee with his/her thesis research mentor. The committee members must be qualified to examine the quality of the research performed during the chosen rotation. Each of them should have expertise in at least one identified area of core knowledge. Once the thesis research mentor confirms that the composition of the committee conforms to the departmental requirements (refer to Section 3.3), the student will send the three areas of core knowledge and the suggested three-member committee to the Director of Doctoral Studies for approval. Once they are approved, the student or the thesis research mentor is cleared to send an invitation to the committee members to participate in the qualifying examination of the student. In general, the qualifying exam **must be completed by June 30** during the first academic year in order to transition to doctoral candidate status; under other circumstances, the student must stand for the qualifying exam no later than the end of the first 10 months in the program. Completion of the qualifying exam is accompanied by the Qualifying Exam Report Form signed by

all committee members indicating the outcome and recommendations for further action. This Qualifying Exam Report Form must be returned to the Doctoral Program Coordinator for approval by the Director of Doctoral Studies and submission to the Graduate School.

2.6 Thesis Committee

Each PhD student will have a thesis committee approved by the Director of Doctoral Studies that will be chaired by the thesis research mentor. The dissertation (thesis) subject must be approved by a Research Advisory Committee (also called “*Dissertation Defense Committee*”), and this approval is obtained by successfully passing the thesis proposal. The Research Advisory Committee monitors the dissertation via a successful dissertation defense. The Research Advisory Committee must follow all guidelines of the Graduate School and consist of five members (the thesis research mentor plus four other members) that meet the following requirements:

Members 1 – 3

BME ‘Primary’ faculty

<https://bme.wustl.edu/faculty/Pages/default.aspx>

or ‘Affiliated’ faculty

<https://bme.wustl.edu/faculty/Pages/affiliated-faculty.aspx> **(At least one of the three members must be a primary BME faculty member).**

Member 4

Faculty inside or outside the BME program (use links above for faculty inside the program).

Member 5

Faculty (or scholar in private sector or government) outside the BME program (he/she must have a doctoral degree and be research active).

Additional requirements:

- (i) One of the five members must be from the Washington University School of Medicine (may be an affiliated faculty member but not required).

- (ii) Four of the five members must be tenured or tenure-track at Washington University. One of these four may be Emeritus.

Upon completion of the qualifying examination, the student will be invited to submit a Dissertation Defense Committee Form (available at the Graduate School and BME website) to the Director of Doctoral Studies for approval. Following approval, the Form is submitted to the Graduate School. The student can then interact and invite the committee members to participate in his/her Research Advisory or Dissertation Defense Committee. Any subsequent changes to the Research Advisory Committee involve completing a new Dissertation Defense Committee Form and submitting it to the Director of Doctoral Studies for approval.

3. DOCTOR OF PHILOSOPHY (PHD) DEGREE REQUIREMENTS

3.1 Academic Requirements

Candidates for this degree must complete a total of 72 credits beyond the bachelor's degree. Of these, a minimum of 36 must be graded graduate coursework and a minimum of 24 must be thesis research (i.e. BME 600). The coursework must fulfill the core curriculum requirement (see Section 4).

To be admitted to candidacy, the student must have completed at least 18 credits at Washington University (including rotation credits), have an overall GPA greater than 3.0, and pass the qualifying examination as described below. He/she must also have finished the training in ethical and responsible conduct of research (the PERCSS Core Curriculum), which can be completed online at <https://research.wustl.edu/percss/> (a digital or paper printout of the training completion should be submitted to the Doctoral Program Coordinator).

3.2 Research Rotation Reports

At the end of each rotation, the student will submit a written document to the rotation mentor satisfying one of the following two options:

(i) Write a report on the research conducted by the student during the rotation. The report should be written in the form of a standard research article and it must include the following: a) student's name; b) title of report; c) semester/year of the rotation; d) rotation mentor's name; and e) date of report. This document should be double-spaced. Although there is no page limitation, the report should be concise and paginated. If the project has not been completed, preliminary or partial results are to be described. It is recommended that this document contain the following sections:

Abstract. In one paragraph, summarize the objectives, methods, main results and conclusions.

Introduction. Describe the motivation for and objectives of the research.

Methods. Give the details of the procedures and calculations.

Results. Describe the results of the study, referring to graphs, tables and illustrations by number.

Discussion. List the main findings and put them in the context of previously-published research on the topic. Discuss the meaning and implications of your results, any surprising findings, sources of error, limitations, etc. Support any assertions by referring to specific data or previously-published research.

References. List pertinent articles using appropriate citation formatting.

(ii) If insufficient data exists for a research report, the student may alternatively write a critical review of a published research article selected by the mentor. This journal article should not be a review article and none of the authors can be associated with Washington University. The review should be no longer than 20 pages of double-spaced text (12 point type with one-inch margins), excluding figures. It is recommended that this review contain the following sections:

Questions addressed. Identify the key questions addressed and the reasons for examining them.

Background. Discuss the most significant relevant research that had been published prior to this article.

Critical Appraisal. Discuss the author’s approach and contribution to the solution of the questions listed above. Compare the author’s approach and contribution to those of previous investigators.

Proposal for additional research. In concrete terms, propose research that might be done to extend and (if necessary) improve upon the study.

References. List pertinent additional articles using appropriate citation formatting.

In both cases, the rotation mentor must approve the report by personally emailing the report (including the selected article for option (ii)) to the Doctoral Program Coordinator (see PhD Checklist on Page 30 for relevant dates). All rotation reports must be submitted prior to the qualifying exam. A grade for the rotation cannot be assigned until after the rotation report is submitted to the Doctoral Program Coordinator.

3.3 Qualifying Examination

Because PhD is primarily a research degree, the qualifying examination is designed to assess the candidate’s aptitude for independent research. After the rotation reports have been submitted to the Doctoral Program Coordinator, the student will select one of the rotation documents as the basis for the qualifying examination. **The student must have completed at least 18 credits at Washington University, finished the PERCSS training, and have a minimum GPA of 3.00 to stand for the qualifying examination.**

In consultation with the chosen thesis research mentor, the student will send (via an online form sent to you by the Doctoral Program Coordinator) three areas of core knowledge and three suggested members of the qualifying examination committee to the Director of Doctoral Studies for approval. This must be done at least one month before the end of the spring semester (see PhD Checklist). The qualifying examination committee will consist of three ‘Primary’ or ‘Affiliated’ faculty members of BME, excluding the research rotation mentor, and shall have at least one ‘Primary’ faculty member of the BME department. Approval of the composition of the qualifying

examination committee will be communicated to you by the Doctoral Program Coordinator.

As part of the qualifying examination, the student is required to identify three areas of core knowledge that are essential to the successful completion of his/her doctoral research. These areas of core knowledge should be within the realm of biomedical engineering. They can be obtained through literature review, independent study, or coursework. It is recommended that these areas of core knowledge be identified in consultation with the thesis research mentor at the beginning of the research rotation although they are not required until the formation of the qualifying examination committee. When the student suggests whom to serve on the qualifying examination committee, he/she should consider those faculty members with expertise in these areas of core knowledge. After the committee is approved by the Director of Doctoral Studies, the student is responsible for scheduling the date and time of the exam with the committee members (allowing at least two hours for the exam). The rotation mentor may attend the exam but cannot ask or answer any questions (except to clarify points of confusion) and cannot vote.

Copies of the rotation report to be used for the qualifying examination are to be distributed to the members of the committee by the student at least two weeks before the date of the exam. The committee will review the qualifying examination report along with the student's transcript and the rotation mentors' evaluations. Failure to submit the qualifying examination report to the committee two weeks prior to the exam is grounds for cancellation or postponement of the examination at the discretion of the Director of Doctoral Studies. A student whose exam is cancelled automatically fails the qualifying examination.

At the time of standing for the qualifying examination, the student will appear before the qualifying examination committee for an oral examination consisting of a brief presentation by the student and questions by the examining committee. The questions may address any issues directly related to the document or the oral presentation

as well as the three areas of core knowledge considered essential to pursuit of doctoral research in the mentor's laboratory. The student may use visual aids or other devices for the presentation of his/her qualifying exam document, *i.e.*, the selected rotation report.

Considering the performance on the oral examination, the written rotation report, the evaluations from all the rotation mentors, the student's coursework, and the student's GPA, the qualifying examination committee will recommend that:

- The student passes the qualifying examination.
- The student must retake the examination.
- The student must successfully pass specified remedial courses or other requirements specified by the committee to pass the qualifying examination.
- The student fails the examination and is asked to leave the PhD program.

Conclusion of a qualifying examination is denoted by a Qualifying Examination Report Form indicating one of the above determinations with suggestions for future direction. The form must be signed by all members of the qualifying examination committee, provided to the Doctoral Program Coordinator, and approved by the Director of Doctoral Studies for the student's record.

3.4 Thesis Proposal

Following successful completion of the qualifying examination, the student and thesis research mentor will decide upon a suitable problem whereupon the student will prepare a comprehensive written research proposal that includes a thorough survey of the field, a discussion of those areas needing further research, and a tentative but clear definition of the proposed research. Results of preliminary or feasibility studies should be included. This proposal will be submitted to the Research Advisory Committee (*i.e.*, the Dissertation Defense Committee, see Section 2.6) at least two weeks prior to an oral presentation and questions before that committee. This should be completed by the end of the third year in the doctoral program. Completion of the thesis proposal presentation will be denoted by a

Pass/Fail/Re-take designation on the Thesis Proposal Report Form signed by the Research Advisory Committee members.

The Research Advisory Committee must be formed and meet shortly after the student passes the qualifying examination in order to be prepared for the thesis proposal. The composition of the Research Advisory Committee may change as the research problem evolves; any changes to the composition of the Research Advisory Committee must be approved by the Director of Doctoral Studies and the Graduate School as described in Section 2.6.

The format of the written proposal should be similar to an NIH research proposal: (1) Specific Aims (1 page), and (2) Research Strategy (6-12 pages max, single spaced, 11 point font, 0.5" margins). 'Specific Aims' are proposed tasks that address a hypothesis (question) or provide technical milestones. Each specific aim should be broad enough to result in one or more publications if successful. 'Research Strategy' should include the following sections: (a) Significance – why is the problem important, what has been done already, what part of the problem will be addressed in the dissertation, (b) Approach – describe in detail experiments or simulations to be performed or devices designed for each specific aim, including preliminary data, which may be unpublished or published by you or your lab, and methods. Ensure that proper controls are performed, and that the number of samples/experiments/simulations is sufficient to answer the question, but not greater than what can be accomplished by one person within a few years. Describe expected outcomes and plans to address pitfalls and complications.

3.5 Mentored Teaching Experience

After passing the qualifying examination but before the thesis defense, PhD students must fulfill a university-wide mentored teaching experience (MTE) in a BME or otherwise approved course. Students are required to have a mentored teaching experience for at least one semester, documented by registering for LGS GSAS 600 Mentored Teaching Experience. This is typically completed during the second year of doctoral training. Students may fulfill this requirement

in many ways including

- Giving lectures in undergraduate classes
- Conducting discussion sessions in undergraduate classes
- Conducting recitation sessions in undergraduate classes
- Giving lectures in laboratory courses that introduce or interpret the experiments
- Conducting help sessions in which the graduate student explains the background and methodology of engineering approaches (involving a lesson plan)
- Holding office hours
- Grading assignments or exams

In the 2020-2021 academic year, instructional delivery will shift significantly from historical in-person teaching to each course having a substantive on-line, or on-line only delivery mode. Consequently, students seeking to fulfill the MTE requirement are expected to shift their contributions accordingly. During this period, the role of the student assistant to the instructors (AI) will primarily be to prepare materials for online delivery in a pedagogically meaningful manner. They will work with their faculty instructor to do the following:

- Edit traditional lecture delivery into “chunked” shorter segments based on thematic topics
- Generate comprehension quizzes and online assessments appropriate to the course
- Moderating chat during synchronous lecture delivery
- Facilitating in-person labs and instruction either on-site with appropriate PPE or remotely
- Moderating small group discussions online (i.e., through breakout rooms and discussion boards)
- Participate in training opportunities offered to learn use of instructional tools online

PhD students are also required to deliver a minimum of four oral presentations at journal clubs, seminar series, scientific conferences,

or retreats. Presentations given as part of the MTE, lab meetings, or thesis committee meetings will not satisfy this requirement. The student should document the fulfillment of this requirement and submit it to the thesis research mentor for approval. The approved document should then be submitted to the Doctoral Program Coordinator.

In addition, PhD students should complete the MTE orientation before the start of their second year of doctoral studies and attend two approved workshops conducted by the Teaching Center before the end of their third year of doctoral studies. Documentation of attendance by the Teaching Center will be used to verify this requirement. Information on the teaching training and workshops can be found at <http://teachingcenter.wustl.edu/>

3.6 Thesis Defense

Upon completion of the thesis, the PhD candidate must present the thesis in a public forum and successfully defend the thesis before a committee consisting of the approved Research Advisory Committee (*i.e.*, the Dissertation Defense Committee) plus additional faculty as required. For PhD candidates, the Title, Scope and Procedure Form (see graduateschool.wustl.edu) must be registered in Graduate School **at least six months before the dissertation examination, or by the end of the fourth year, whichever comes first**. The dissertation must be approved by the Research Advisory Committee as part of the final examination. For the requirements of the composition of the Research Advisory Committee, please see Section 2.6.

The student must not stand for the defense until after the acceptance of one first-author paper in a peer-reviewed journal and should not stand for the defense before the submission of a second first-author manuscript to a peer-reviewed journal.

4. COURSE SELECTION

Students formulate their course program in consultation with their academic adviser and/or thesis mentor. A core curriculum is required

to be completed by all PhD students. This core curriculum requires:

- One graduate course in the area of life science (≥ 3 credits)
- One graduate course in the area of mathematics (≥ 3 credits)
- One graduate course in the area of computer science or exemption by proficiency (≥ 3 credits)
- Four BME courses as specified below.

The BME courses of the core curriculum are four courses from the list starting on next page. Other courses may fulfill this requirement and may be added to this list at the discretion of the Director of Doctoral Studies by petition of the student.

Up to six credits of BME 601C Research Rotation and/or three credits of BME 501 Graduate Seminar may be counted towards the 36 credits of graduate coursework required for the PhD degree. Therefore, at least nine additional graduate courses (about 27 credits), including the core curriculum that represents six to seven courses, are required for the PhD degree. Of these nine courses, up to two 400-level courses may be counted towards the coursework requirement.

Graduate courses may be transferred in (up to 24 credits) but must be evaluated and approved by the Director of Doctoral Studies and the Graduate School. In general, these courses should be the ones that are not counted toward your bachelor degree. Up to three credits of research rotation credit will be assigned for completion of a thesis at the Master's level. The evaluation and approval may occur at any time but course transfer does not become official until after one year in residence at Washington University. For credit transfer, please provide the following materials (electronic versions preferred) to the Director of Doctoral Studies:

- Transcript where the courses to be transferred are listed
- Descriptions and/or syllabi of the courses to be transferred

Additional materials may be required. In your request (email

preferred), all the courses to be transferred and their equivalent courses at Washington University should be listed in the following format:

Transfer Course Title – # Credits of Course Type (Equivalent Course at Washington University)

Example:

Soft Tissue Biomechanics –3 Credits of BME course (BME 563 Orthopedic Biomechanics – Bones and Joints)

If there is any course for which you cannot find an equivalent course at Washington University, this course may be transferred as a general elective or into an area determined at the discretion of the Director of Doctoral Studies.

Courses that fulfill the BME requirement

BIOL 5146	Principles and Applications of Biological Imaging
BIOL 5147	Contrast Agents for Biological Imaging
BIOL 5311	Dynamics in Mesoscopic Molecular Systems
BIOL 5312	Macromolecular Interactions
BME 422	Kinetic in Cell Signaling and Metabolism
BME 471	Bioelectric Phenomena
BME 502	Cardiovascular MRI
BME 507	Radiological Physics and Dosimetry
BME 5071	Radiobiology
BME 5072	Radiation Oncology Physics
BME 5073	Radiation Protection and Safety
BME 511	Biotechnology Techniques for Engineers
BME 521	Kinetics of Receptor-Mediated Processes
BME 523	Biomaterials Science
BME 524	Tissue Engineering
BME 525	Engineering Aspects of Biotechnology
BME 527	Design of Artificial Organs

BME 532	Physics of Biopolymers and Bioinspired Polymers
BME 533	Biomedical Signal Processing
BME 537	Computational Molecular Biology
BME 541	High Throughput Systems Biology
BME 542	Biomacromolecules Design and Engineering
BME 543	Molecular and Cellular Engineering
BME 544	Biomedical Instrumentation
BME 556	Experimental Methods in Biomechanics
BME 5565	Mechanobiology of Cells and Matrices
BME 557	Cell and Subcellular Biomechanics
BME 558	Biological Transport
BME 559	Intermediate Biomechanics
BME 5610	Protein Structures and Dynamics
BME 562	Mechanics of Growth and Development
BME 563	Orthopedic Biomechanics – Bones and Joints
BME 564	Orthopedic Biomechanics – Cartilage/Tendon
BME 565	Biosolid Mechanics
BME 567	Cardiac Mechanics
BME 568	Cardiovascular Dynamics
BME 570	Mathematics of Image Science
BME 572	Biological Neural Computation
BME 573	Applied Bioelectricity
BME 574	Quantitative Bioelectricity and Cardiac Excitation
BME 575	Molecular Basis of Bioelectrical Excitation
BME 5771	Biomedical Product Development
BME 5772	Biomedical Business Development
BME 5820	Fundamentals and Applications of Modern Optical Imaging
BME 589	Biological Imaging Technology
BME 5901	Integrative Cardiac Electrophysiology
BME 5903	Physical Methods for Biomedical Scientists
BME 5907	Advanced Concepts in Image Science
BME 591	Biomedical Optics I: Principles
BME 5910	Reverse Engineering the Human Brain

BME 592	Biomedical Optics II: Imaging
BME 593	Computational Methods for Inverse Problems
BME 594	Ultrasound Imaging
CSE 568M	Imaging Sensors
ESE 438	Applied Optics
ESE 482	Digital Signal Processing
ESE 546	Dynamics & Control in Neuroscience
ESE 588	Quantitative Image Processing
MEMS 5560	Interfaces and Attachments in Natural and Engineered Structures
MEMS 5608	Introduction to Polymer Science & Engineering
MEMS 5913	Biomaterials Processing
MEMS 5914	Polymeric Materials Synthesis and Modification
MEMS 5912	Biomechanics Journal Club
PSYCH 4450	Functional Neuroimaging Methods

Courses that fulfill the life science requirement

BIOL 404	Laboratory of Neurophysiology
BIOL 4580	Principles of Human Anatomy & Development
BIOL 4071	Developmental Biology
BIOL 4810	Biochemistry I
BIOL 4820	Biochemistry II
BIOL 5051	Foundations in Immunology (4 credits)
BIOL 5053	Immunobiology (4 credits)
BIOL 5062	Central Questions in Cell Biology
BIOL 5068	Fundamentals of Molecular Cell Biology
BIOL 5224	Molecular, Cell, and Organ Systems
BIOL 5285	Fundamentals of Mammalian Genetics
BIOL 5319	Molecular Foundations of Medicine
BIOL 5352	Developmental Biology
BIOL 5357	Chemistry and Physics of Biomolecules

BIOL 548	Nucleic Acids and Protein Biosynthesis
BIOL 5488	Genomics (4 credits)
BIOL 5571	Cellular Neurobiology (4 credits)
BIOL 5581	Neural Basis of Acoustic Communication
BIOL 5651	Neural Systems (6 credits)
BIOL 5663	Neurobiology of Disease
BIOL 5665	The Science of Behavior
BME 503A	Cell & Organ Systems
BME 530A	Molecular Cell Biology for Engineers
BME 538	Cell Signal Transduction
BME 5902	Cellular Neurophysiology
BME 5909	Physiology of the Heart

Courses that fulfill the mathematics requirement

Biol 5075	Fundamentals of Biostatistics for Graduate Students (2 credits)
BME 570	Mathematics of Image Science
BME 5912	Applied Mathematics for Biomedical Sciences
BME 593	Computational Methods for Inverse Problems
EECE 503	Mathematical Methods in EECE
ESE 501	Mathematics of Modern Eng. I
ESE 502	Mathematics of Modern Eng. II
ESE 517	Partial Differential Equations
ESE 520	Probability and Stochastic Processes
MATH 415	Partial Differential Equations
MATH 449	Numerical Applied Mathematics
MATH 475	Statistical Computing
MATH 494	Mathematical Statistics
PHY501	Methods of Theoretical Physics I
PHY502	Methods of Theoretical Physics II
PHY503	Advanced Math Methods for Physicist & Eng. I
PHY504	Advanced Math Methods for Physicist & Eng. II

PHY581 Critical Analysis of Scientific Data (1 credit of math, 2 credits of general electives)

Courses that fulfill the computer science requirement*

BME 550 Numerical Methods for Computational Modeling in Biomedicine

BME 5913 Molecular Systems Biology: Computation & Measurements for Understanding Cell Physiology and Disease

CSE 501N Introduction to Computer Science

CSE 502N Data Structures and Algorithms

CSE 504N Object-oriented Software Development Laboratory

CSE 511A Introduction to Artificial Intelligence

CSE 515T Bayesian Methods in Machine Learning

CSE 517A Machine Learning (Prereq: CSE 417T)

CSE 541T Advanced Algorithms

CSE 543T Algorithms for Nonlinear Optimization

CSE 554A Geometric Computing for Biomedicine

CSE 555A Computational Photography

CSE 559A Computer Vision

CSE 587A Algorithms for Computational Biology

MEMS 5515 Numerical Simulation in Solid Mechanics I

* The computer science requirement may also be fulfilled by petition to the Director of Doctoral Studies documenting at least one undergraduate course in computer programming and an example of the original code written by the student (note that Matlab or Mathematica is not considered a programming language).

Additional courses may fulfill the life science, mathematics or computer science requirements, dependent upon your background and at the discretion of the Director of Doctoral Studies with consultation with the thesis research mentor.

The normal load for a PhD student is nine to ten credits per semester. Students will be graded for a three-credit course for each semester on which they engage in research rotations; typically, any three-credit course is expected to require nine total hours per week of course-related activity. In practice, research rotations consist of at least 15-20 hours per week in the laboratory during the period in which classes are in session. This is considered the minimum necessary research activity in order to be successful in the rotation.

Following selection of the thesis research mentor, the student should choose the remaining coursework in consultation with the thesis research mentor and/or academic adviser.

All PhD degrees awarded by Washington University are awarded through the Graduate School. For additional requirements for the PhD degree, see the Graduate School Bulletin:

http://graduateschool.wustl.edu/current_students/degree-requirements

5. FINANCIAL ASSISTANCE

Graduate students pursuing doctoral research in the department will normally receive some form of support for stipend and tuition remission during their enrollment as full-time students. Academic achievements and satisfactory performance in research and other assignments while at Washington University are the primary factors governing continuation of financial assistance. Students who are placed on academic suspension will automatically have their financial assistance canceled, effective with the date of suspension. (For the regulations governing academic probation and suspension, please refer to the Graduate School website,

http://graduateschool.wustl.edu/files/graduateschool/imce/reviseapproved_policy_on_probation_and_dismissal_for_academic_reasons_5.16.17.pdf)

5.1 Types of Awards

There are four types of financial assistance awards available to graduate students in the department:

a. Fellowships

Fellowships are grants generally providing full tuition plus a stipend. Fellowship funds may derive from government or private sources. They may be administered by the department or they may be awarded directly to the student by an external agency, e.g., the National Science Foundation. (In the case of NSF, Hertz, DOD, DOE, UNCF or similar fellowships, students must apply directly to the foundation and notify the Doctoral Program Coordinator in compliance with the federal guidelines).

b. Traineeships

Traineeships may be funded by the James McKelvey School of Engineering or the School of Medicine, administered by the departmental chair, or associated with specialized externally-sponsored training grants. In the latter case, the traineeship has a definite term (9 or 12 months) and is generally renewable depending upon academic performance and continuation of the grant. Holders of such traineeships are normally obliged to follow a course program specified by the particular training grant.

Traineeships funded by the university are normally awarded through a competitive evaluation process. They provide a component of tuition remission per semester plus a stipend. Students must apply directly to the training grant program upon recommendation of the thesis research mentor and must notify the Doctoral Program Coordinator of any decision for traineeship support.

c. Assistantships to Instructors

Assistantships to instructors are funded by the department. They are normally awarded to students who have expressed an interest in a teaching career and who have acceptable English language skills. The duties of the assistant to the instructor are similar to the

teaching requirement with the following exceptions. An assistant to the instructor normally includes the grading of papers, laboratory reports, and/or laboratory supervision in undergraduate courses.

Those requesting assistantships to instructors must apply for the position and applications will be accepted from PhD students, MSc students and post-docs. Matches are made by the Doctoral Program Coordinator and assistants to instructors are responsible to the professors in charge of the various courses and laboratories. The average time is not to exceed 20 hours per week.

d. Research Assistantships

Research assistantships generally provide a stipend and some tuition from government or industry grants and contracts. They are normally awarded to students who have advanced to candidacy and made a commitment to a particular research area and who, by virtue of their academic background and record, satisfy a particular project's needs.

Research assistantships may be supplemented by tuition scholarships that may be funded jointly by the James McKelvey School of Engineering and the School of Medicine. Research assistants are responsible to the project director (principal investigator) of the project. (Generally, this same individual eventually assumes the additional role of thesis or dissertation mentor.)

5.2 Outside Employment

Holders of fellowships, traineeships and assistantships are required to devote their 100% effort to graduate studies. They are not permitted to engage in any outside employment without special permission of the Director of Doctoral Studies and the Department Chair of Biomedical Engineering.

External Professional Activity for Full-Time PhD Students in the James McKelvey School of Engineering

If approved by their thesis research mentor in writing, doctoral

students may engage in limited external professional activity. Student groups that provide consulting services are also included, and acceptance of a project through these organizations must be approved by the thesis research mentor and the Director of Doctoral Studies. Any professional activity associated with a faculty member's personal company or affiliated companies must follow all the guidelines and be reviewed by the university's Conflict of Interest Review Committee (CIRC). Any proposed activity outside of the engagement of research must be disclosed before the activity may begin.

It is expected that external professional activity will be conducted in a way that will not interfere with their research as part of the research assistantship, nor impede in any manner progress toward completion of the doctoral degree. International students will also have to receive approval from the university's Office for International Students and Scholars. The Research Advisory Committee must be informed and routinely updated on all external professional activities. Departments may have additional oversight, guidelines and restrictions for their own doctoral students' involvement in external professional activity.

5.3 Time Off

Graduate students receiving awards are expected to commit themselves fully to their studies and research regardless of whether classes are in session. Intersession periods listed in the University Academic Calendar only denote times when classes are not in session. Graduate students in residence should, however, utilize these periods to further their studies and research. Intersession periods are not time off for graduate students receiving a stipend and students are expected to learn full time on research during these periods.

Students on full stipends are permitted to stop their studies and research for a maximum of two weeks during the calendar year. In addition, students are permitted to take the university-scheduled holidays. Additional time off can be arranged but must be approved ahead of time by the research mentor (once selected) or

the Director of Doctoral Studies (before the selection of a research mentor). Absences of research assistants must be scheduled so as not to impede the progress of an ongoing research project and should be cleared with the research mentor.

6. OTHER POLICIES

6.1 Seminars

Each year the department sponsors or participates in a series of seminars by visiting lecturers or Washington University faculty and students. All full-time graduate students are required to enroll in BME 501 Graduate Seminar, which is a pass/fail course carrying zero or one credit (BME 501 for 0 credit and BME 501C for 1 credit). **First year students should take BME 501 for zero credit until they pass their qualifying exams.** A passing grade is required for each semester for all full-time students and is earned by regular attendance at these events. Up to three credits of BME 501C Graduate Seminar may be counted towards the 36 credits of graduate coursework required for the PhD degree. For one credit, the student must submit to the Doctoral Program Coordinator a two-page critique of a research paper (not a review article or an article from the student's own lab) written by one of the seminar speakers. This critique will be reviewed and graded by the Director of Doctoral Studies.

6.2 Secretarial Service

Department secretaries do not generally provide clerical services to graduate students except in connection with scheduled courses, student groups, and sponsored research projects.

6.3 Copying Service

Graduate students may not charge copying services to the department or a research project without prior authorization. Personal copies can be charged to a student's personal account. The cost of copying dissertations is considered a personal obligation.

This is a compilation of policies and regulations applicable to the graduate students in the Department of Biomedical Engineering. Students should also become familiar with the general regulations of the Graduate School of Arts & Sciences as described in the school's website at <http://artsci.wustl.edu/GSAS> and the James McKelvey School of Engineering as described in the school's website: engineering.wustl.edu

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Doctoral Program Coordinator

Suesy Seel
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PhD Checklist

<u>Completed</u>	<u>Item</u>	<u>Due Date</u>	<u>Submit to</u>
_____	Rotation Preference Form	Friday first week of classes	Doctoral Program Coordinator
_____	1 st Rotation Report <i>(signed by mentor)</i>	Jan 10, 2021*	Doctoral Program Coordinator
_____	2 nd Rotation Report (optional) <i>(signed by mentor)</i>	May 13, 2021*	Doctoral Program Coordinator
_____	Submit First Year Progress Update form each semester. Schedule exam as soon as your committee is approved by DDS	1 rotation – Dec 1 2 rotations – April 1	Doctoral Program Coordinator
_____	Completed PERCSS training	Before Qual Exam	
_____	Rotation report for qualifying examination	2 weeks prior to exam date	Qualifying Exam Committee
_____	Qualifying Exam Completed Submit Qualifying Examination Report – Doctor of Philosophy (Form signed by committee)	June 30	Doctoral Program Coordinator
_____	Proposed Thesis Committee	End of 2 nd year	Director of Doctoral Studies & Doctoral Program Coordinator
_____	Attended MTE Orientation and completed LGS GSAS 600	End of 2 nd year	Doctoral Program Coordinator
_____	Attended two MTE Workshops	End of 3 rd year	Doctoral Program Coordinator

* If a rotation ends early, the due date will be two weeks after the end of the rotation.

Checklist continued on next page

_____	Teaching Requirement (oral presentations) Fulfilled – Submit Teaching Requirement Fulfillment form (signed by the thesis research mentor)	Immediately upon completion of requirement	Doctoral Program Coordinator
_____	Thesis Proposal Scheduled	June 1 (of 3 rd year)	Director of Doctoral Studies & Doctoral Program Coordinator
_____	Thesis Proposal (Written) Completed	2 weeks prior to proposal date or June 30 of 3 rd year (whichever is earlier)	Thesis Proposal Committee
_____	Thesis Proposal (Oral) Completed (submit Thesis Proposal Report form signed by committee)	August 31 of 3 rd year or 12 months prior to defense (whichever is earlier)	Doctoral Program Coordinator
_____	Title, Scope and Procedure submit Title, Scope & Procedure form signed by committee)	Submit with Thesis Proposal	Doctoral Program Coordinator
_____	Annual update with Thesis Committee	Meet at least once every 12 months with committee members	
_____	Denote peer-reviewed paper acceptances		PI & Doctoral Program Coordinator
_____	Schedule thesis defense	2-3 months prior to date	Director of Doctoral Studies & Doctoral Program Coordinator
_____	Submit Thesis	2-4 weeks prior to date	Thesis Committee
_____	Thesis Defense (submit Examination Approval form to be signed by committee)		Doctoral Program Coordinator

Please see Graduate School website for procedures on Intent to Graduate and Dissertation submission. (http://graduateschool.wustl.edu/current_students)

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Fall 2020